THE ROCKEFELLER UNIVERSITY
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30 January 1979

TO: Joshua Lederberg, President

FROM: George A. Miller

RE: Cognitive Neuroscience

During our conversation on Friday, 26 January 1979, you requested a memorandum summarizing what I told you about cognitive neuroscience. I hope the following will cover the major substantive points discussed with you and with Rodney Nichols.

Scope of work. Although a succinct definition of cognitive neuroscience (cns) remains to be written, the intention is to bring cognitive psychology together with certain parts of neuroscience, in the hope of discovering neurophysiological correlates of cognitive functions in man. I tend to think of it as the branch of physiological psychology concerned with higher mental processes in human beings.

Cns should differ from neuropsychology, which has developed a testing function that provides for neurologists and neurosurgeons much the same psychometric information that clinical psychologists have long provided to psychiatrists. Cns should develop theories of perception, memory, attention, preference, language, and problem solving that: (a) are adequate to account for experimental data from normal human subjects; (b) are consistent with clinical observations of neurological patients; (c) relate to any comparable data obtainable with animals; (d) suggest prosthetic devices exploiting advances in artificial intelligence.

Examples. Lacking an a priori definition, cns will probably develop around the study of particular types of neurological patients. Examples of syndromes of interest for cognitive psychology are the following.

Amnesia. There is a characteristic loss of memory, both retrograde and anterograde, associated with CVA. Neuropsychologists have developed techniques for probing the scope and density of such amnesias. Cns would be concerned to relate those observations to current theories of learning, memory, and forgetting in normal people. Of particular interest are those relatively rare patients who appear to function normally except that they have lost the ability to transfer information from short term (up to about a minute) to long term memory. The classic case is HM,

whose hippocampus was bilaterally excised to relieve epilepsy and who has been the subject of about a dozen experimental studies that provide the firmest available evidence for the validity of the distinction between short and long term memory. Various techniques for the externalization of memory are possible for intelligent and motivated patients, which can make them less of a burden for their families, but little thought has yet been given to automation of these techniques.

Split brain. In order to prevent the spread of epileptic activity, the hemispheres are sometimes surgically disconnected by cutting the corpus callosum. These patients have been an extremely rich source of data concerning the lateralization of cognitive functions in man, e.g., the relation between language and conscious awareness.

Neglect. A puzzling syndrome, usually associated with right parietal lesions, consists of inattention to the left visual field. Chronometric techniques developed by psychologists, combined with records of averaged evoked potentials from both hemispheres, are expected to provide valuable data on the neurological mechanisms involved in the control of attention.

Aphasia. Since Broca it has been known that lesions (usually) in the left hemisphere can interfere with speech and language functions. Anterior lesions characteristically result in a kind of telegraphic speech; posterior lesions in a kind of neologistic jargon; several other types of aphasia have been described in the extensive literature. In recent work that repeated standard psycholinguistic experiments with aphasic patients, it has been shown that defects of comprehension closely parallel defects of language production. The precise characterization of the nature of the defects requires collaboration of neurologists, psychologists, and linguists, which should be an ideal project for cns. Theoretically, when the nondominant hemisphere is intact it should be possible to retrain it to serve at least limited linguistic functions, but most aphasiologists believe that training techniques currently used have been ineffective with adult aphasics.

Dyslexia. This term is commonly used of children with reading difficulties that are probably social or educational in origin, but there are many cases of congenital and acquired dyslexia clearly associated with neurological abnormalities or lesions. These patients should provide valuable tests of cognitive theories of reading developed by psychologists. Of special interest is deep dyslexia (which might be characterized as a type of aphasia) in which the patient "reads" a word by speaking an associated word (e.g., shown mouse, he might say rat or cheese); it is hoped that these patients will provide information about the functional organization of lexical memory in normal people.

There are probably other psychologically interesting opportunities that have not yet been identified (e.g., the various cognitive handicaps of Alzheimer's syndrome), but this is not

intended to be a complete catalogue. My point is that cognitive psychology has now developed to the stage where its theories and methods can be applied to the study of a wide range of neurological symptoms, and this application would provide a central task for cns. (Gazzaniga sees the focus of cns somewhat more broadly, but I am unable to speak authoritatively for him.)

Personnel. Michael Gazzaniga, a neuropsychologist in the Department of Neurology, Cornell Medical School, has taken the lead in organizing a program to develop cns. Gazzaniga, a student of Roger Sperry, is best known for his continuing studies of split brain patients. In his group is Bruce Volpe, a neurologist, and several postdoctoral fellows. From Rockefeller, George Miller and William Hirst have been his principal collaborators, although William Estes and Floyd Ratliff have expressed interest in particular aspects of the program. Michael Posner, Professor of Psychology at the University of Oregon (and brother of Cornell neurologist Jerry Posner), joined the group as of January 1979 on a six-month leave of absence.

Facilities. New York Hospital provides a continuing supply of interesting neurological patients for study, and each patient can be examined with the full range of techniques available to the Neurology Department; Fred Plum, Chairman of the Department, has promised full cooperation. I shall list only the special facilities available to the program.

Mobile laboratory. NSF has provided Gazzaniga with a van equipped with audio and television recording equipment and other scientific instruments used in testing patients. This mobile laboratory makes it possible to study patients who are unable or unwilling to come to York Avenue.

Rockefeller Hospital. Kappas has welcomed our use of beds in the hospital to accommodate patients we wish to study intensively over the course of a week or so, and has appointed Bruce Volpe to the hospital staff to oversee the care of those patients while they are in residence.

Positive Emission Tomography (PET). PET is expected to be the technological breakthrough of the 1980s, and NIH has decided to support a small number of such installations at selected medical centers around the country. Radioactive tracers injected into the bloodstream can reveal the pattern of metabolic activity in different regions of the brain during different cognitive tasks. Jerry Posner has taken the initiative in submitting an application for a PET to be shared by Memorial Hospital-SKL and New York Hospital-Cornell; he is optimistic because Memorial already has a cyclotron that would be half the cost of this expensive facility.

Funding. Gazzaniga has received $220,000 from the Sloan Foundation to conduct joint Cornell-Rockefeller workshops in cns during 1978-1980, and has been promised $450,000 for a joint Cornell-Rockefeller

postdoctoral training program in cns (1980-1983). In addition, NIMH has encouraged him to expect a small postdoctoral training grant ($420,000 for five years, 1979-1984). Thus, $1,090,000 should be available (in addition to any specific research grants) to support the program over a period of five years. If the Sloan Foundation judged the program a success, there is a possibility of an additional large grant for cns in 1983. The consequences of terminating Rockefeller participation has not been explored with Sloan or NIHM.

Activities. During the Fall of 1978 Miller and Hirst led a seminar in cognitive psychology attended by members of Gazzaniga's and Miller's laboratories; during the Spring of 1979 Gazzaniga and Volpe are offering a seminar in clinical neurology for the same group. A major goal is to learn each other's languages and methodologies.

During the Spring of 1979 a series of five one-week workshops on different topics in cns will be conducted jointly by the group, and as part of that series each visitor will present a public lecture on his own research. The visitors will be Roger Shepard, Russell DeValois, John Marshall, Edgar Zurif, David Premack, Floyd Bloom, Emilio Bizzi, Leon Festinger, Stephen Hillyard, and Donald MacKay. In closed sessions, critical discussion of their lectures will be led by S. Murray Sherman, Walter Ritter, Donald Reis, Michael Posner, Rodolfo Illinas, and Gary Lynch. A report on these workshops will be prepared for Sloan by Posner and Gazzaniga; if an integrating theme emerges, the report should constitute a publishable book.

Gazzaniga has advertised the Program in Cognitive Neuroscience for applicants for postdoctoral positions. Initial responses have come from highly qualified people in both neurology and cognitive psychology, and some predoctoral candidates have inquired about the possibility of graduate training in cns.

Prognosis. The mind-brain relation is not only an ancient problem -- it is so difficult that many philosophers believe we have made a category mistake. Nevertheless, we now know a great deal more about it than Descartes did, and further knowledge is accumulating at an accelerating rate. To anyone contemplating the prospects for cns, however, a critical question concerns whether cognitive psychology is yet mature enough to contribute to the characterization of mental and behavioral facts that neuroscience should be expected to explain. I believe that there are a few psychologists (like Posner and Gazzaniga) who combine the experimental skills and dedicated enthusiasm to make substantial progress. But it will be a difficult, and sometimes discouraging, enterprise.